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Environmental Kuznets curve in Romania and the role of energy consumption

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ABSTRACT

The aim of present study is to probe the dynamic relationship between economic growth, energy consumption and CO_2 emissions for period of 1980–2010 in case of Romania. In doing so, ARDL bounds testing approach is applied to investigate the long run cointegration between these variables. Our results confirm long run relationship between economic growth, energy consumption and energy pollutants. The empirical evidence reveals that Environmental Kuznets curve (EKC) is found both in long-and-short runs in Romania. Further, energy consumption is major contributor to energy pollutants. Democratic regime shows her significant contribution to decline CO_2 emissions through effective implementation of economic policies and financial development improves environment i.e., reduces CO_2 emissions by redirecting the resources to environment friendly projects.

Contents

1. Introduction

Positioned in the Central-Eastern Europe, Romania is an upper-middle income EU (European Union) member economy, with a dynamic economic development. Before 1990, Romania was a communist country, with a hyper-centralized economy. After the fall of the communist regime in 1989, the Romanian economy registered instability and seriously decreased in the level of GDP, with high amount of unemployment and inflation. The main factors were the inefficiency of the public administration, corruption, and the lack of real structural reforms. Actual Romanian economy is based on services, which represent 55% of GDP. The industry and agriculture cover 35% of GDP and 10% of GDP, respectively.

Regarding the total nominal GDP, Romania is the 11th largest economy in the EU and the 8th largest based on purchasing power parity. With its emerging economy, Romania becomes the world's 49th largest economy. Since 2000 a strong growth trend started, which is the best economic period in the whole Romanian history. More, Romania's integration in European Union (EU) on 1st of January 2007 illustrated another important factor for the country's development. The country hopes to adhere at Schengen Agreement Treaty by 2011 and to adopt euro by 2014.

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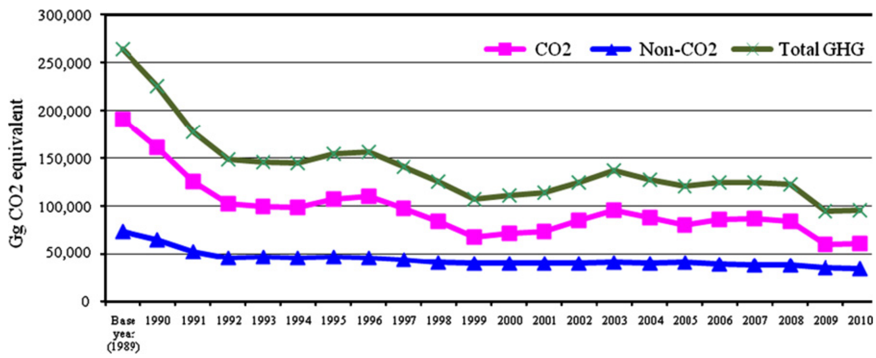

Fig. 1. CO_2, Non-CO_2 and GHG emissions with land use, land-use change and forestry (LULUCF), in Romania, (1989–2010).
Source: United nations framework convention on climate change, GHG data, (2012).

In Romania, the environment policy is a new component of general state policy since 1990, when it has been founded, for the first time in the history, the Environment Department. Two main objectives of this authority can be formulated: the limitation of pollution phenomena, and the establishing of responsibility regarding environmental damage. In 1992 it has been adopted the first official document for environment conservation and protection – National Strategy of Environment Protection – updated in 1996 and 2002, in accordance with European regulations in the field. On the other hand, Romania is the 38th largest energy consumer in the world and the largest in South Eastern Europe. More, the country is an important producer of natural gas, oil and coal in Europe. In 2005, the total energy consumption of Romania was structured as follows: 36.4% – natural gas; 25.1% – oil and derivates; 22.4% – coal and coke, and 16.1% – hydro and others. The main resources used in the production of electric energy are the coals (about 70% in total), the hydrocarbons (about 25% in total), renewable energy and other fuels (Table A1, in Appendix). The lignite, pit coals and other coals are the main type of coals used in the energy sector (Table B1, in Appendix). In the period 2007–2010, in Romania, the consumption of lignite and other coals are relatively constant (about 90% in total, with equal parts for each type of coal), but slightly decreased in detriment of energetic pit and brown coals. On the other hand, the main liquid hydrocarbons used for the production of electric energy are: the oil fuel (tar) and “M” type fuel (Table C1, in Appendix). As Table C1, in Appendix, shows, the natural gas, refinery gas (including propylene) and liquefied petroleum gas (LPG) are also main resources for the energy sector. Regarding the GHG resources’ profile, Table D1 in Appendix reveals that, for European countries (e.g., Romania), the lignite occupies the first position, with 1.060–1.690 kg CO_2-equiv./kW h, while the oil is third, with 0.519–1.190 CO_2-equiv./kW h.

Even if these resources are very important for energy sector, the issue of shale gas raised a high interest in the last years. According to U.S. Energy Information Administration, a group of three East-European countries (Romania, Bulgaria and Hungary) has a great potential of shale gas reserves (about 538 billion cubic meters). In Romania, since 2010 the Romanian government already has offered as concession 870,000 ha in the Eastern plains and the Black Sea coastal aria. Despite of several civil protests, the Romanian Parliament has overwhelming rejected a motion to ban shale gas exploration and exploitation by hydraulic fracturing.

Before 1989, during the communist period, the CO_2 emissions registered high levels (i.e., over 200,000 Gg CO_2)[1]. After 1990, the CO_2 emission presets a descendent tendency, from 161,343.4 Gg CO_2 in 1990, to 61,329.2 in 2010 (Fig. 1). As the non-CO_2 emission is constant on the considered interval, the same tendency has the greenhouse gas (GHG) emissions: from 264, 495.5 Gg CO_2 in 1989 to 95, 545.3 Gg CO_2 in 2010.

These two evolutions have two main common causes: first one, the major changes in the economic size and structure after 1989, and second one, the harmonization of Romanian environment legislation with the European one. Regarding the CO_2 (GHG as well) generated by economic sectors, after 1989, only the emissions in transport, LULUCF and waste have registered annual increase, while the emission of CO_2 for the rest of sectors pronouncedly degreased, as Fig. A1 in Appendix shows. In 2010, the Romanian Government has approved the decision to sell CO_2 emission certificates. The Romanian authorities has estimated this operation well generate 2 billion euro in term of cash-flow.

Kuznets [1] has intuited a relationship between per capita income and income inequality as an inverted-U-shaped curve. More precisely, if the per capita income increases, then the income inequality also increases at first and starts declining after a turning point. Based on this idea, a group of authors has performed a new hypothesis: the existence of an inverted U-shaped relationship between per capita GDP and measures of environmental degradation (Grossman and Krueger [2,3]; Panayotou [4,5]; Selden and Song [6]; Shafik and Bandyopadhyay [7]; Hettige et al. [8]; Koop [9]; Stern [10]; Copeland and Taylor [11]; Soytas et al. [12]; Ang [13]; Soytas and Sari [14]; and more recently Borhan et al. [15]). This curve has been termed as environmental Kuznets curve (EKC). Particular conclusions formulate Holtz-Eakin and Selden [16] and Friedl and Getzner [17], while Agras and Chapman [18] and Richmond and Kaufmann [19] did not find any evidence of EKC.

Other authors have studied the determinants of the EKC, such as: financial development, energy consumption, economic growth and CO_2 emissions (Jensen [20]; Sadorsky [21]; Jalil and Feridun [22]; Luzzati and Orsini [23]; Acaravci and Ozturk [24]; Fodha and Zaghdoud [25], Martinez-Zarzoso and Bengochea-Morancho [26]; Galeotti et al. [27]; Romero-Ávila [28]; Jalil and Mahmud [29]; He and Richard [30]; Iwata et al. [31]; Shahbaz et al. [32]; Apergis and Payne [33]; Nasir and Rehman [34]; Wang et al. [35]; Al-Mulali [36]; Farhani and Rejeb [37], and Arouri et al. [38]). In the case of Romania, the literature regarding EKC is very poor. In this regard, some analyses have been performed by Atici [39]; Tamazian and Rao [40]; and Sova et al. [41] providing ambiguous results.

The paper treats the relationship between energy consumption, economic growth and CO_2 emissions, in case of Romania. The main point of this approach is the existence in Romania of the environmental Kuznets curve’s effects over the period of 1980–2010. Unfortunately, there is a poor literature regarding this complex connection focused on Romania’s case. Based on this argument, the main objective of our investigation is to complete this gap in the literature in the field.

The rest of the paper is organized as follows: Section 2 contains the literature review. Section 3 presents the methodology, variables’

[1] Gg of CO_2 equivalent emissions measure the weight of carbon dioxide released into atmosphere in Giga grams of CO_2).

description and data. Section 4 shows estimation and empirical results. Section 5 concludes.

2. Literature review

For the first time, the relationship between environmental quality and per capita income has been conceptualised by Grossman and Krueger [2]. The authors stress that as economic development proceeds, increasingly intensive and extensive economic activity initially leads to a sullying of the environment. Particular results obtained Holtz-Eakin and Selden [16] and Friedl and Getzner [17]. The first authors indentify a monotonic rising curve, while the second group of researchers demonstrates the evidence of an N-shaped curve. On the contrary, for Chowdhury and Moran [42], the empirical evidence regarding EKC remains equivocal: some case studies that appear to support the key EKC hypotheses are contradicted by others that fail to demonstrate environmental recovery following increasing indices of economic development. No significant relationship between economic growth and environmental pollutants also claim Agras and Chapman [18] and Richmond and Kaufman [19].

Kijima et al. [43] show that theoretical models on the EKC relationship can be classified into several categories: static vs. dynamic, macroeconomic vs. microeconomic, long term vs. short term, and deterministic vs. stochastic. According to Stern [10] and Copeland and Taylor [11], the literature review about environmental Kuznets curve reveal that an inverted U-shaped relationship may be determined by a several factors such as: (i) economies of scale in pollution abatement; (ii) changes in the industry mix; (iii) evolution from intensive physical capital towards more human intensive capital activities; (iv) changes in input mix; (v) changes in the elasticity of income to the marginal damage generated by environmental degradation; and (vi) changes in environmental regulation.

Sadorsky [21] has performed an analysis based on a panel dataset on 22 emerging countries covering the period 1990–2006. The main results illustrate a positive and statistically significant relationship between financial development and energy consumption. Studying the China's case, from 1953 to 2006, the results of Jalil and Feridun [22] allow a negative sign for the coefficient of financial development, suggesting that financial development has not taken place at the expense of environmental pollution.

Luzzati and Orsini [23] study the relationship between absolute energy consumption and gross domestic product (GDP) per capita, in the case of 113 countries, over the period 1971–2004. They find that the estimates cannot support an energy-EKC hypothesis. One year after, Acaravci and Ozturk [24] examine the causal relationship between carbon dioxide emissions, energy consumption, and economic growth using an autoregressive distributed lag (ARDL) bounds, for 19 European countries. The results show a positive long-run elasticity estimate of emissions with respect to energy consumption only in Denmark, Germany, Greece, Italy, and Portugal.

Fodha and Zaghdoud [25] investigate the relationship between economic growth and energy pollutants for a small and open developing country—Tunisia, during the period 1961–2004. They find an inverted U-shaped relationship between SO_2 emissions and GDP per capita, with income turning point approximately equals to $1.200 (constant 2000 prices). Martinez-Zarzoso and Bengochea-Morancho [26] apply the Pooled Mean Group Estimator test to investigate the environmental Kuznets curve for CO_2, in 22 OECD countries. This approach stresses that there is an N-shaped EKC for the majority of the analyzed countries. Galeotti et al. [27] formulate two main conclusions: published evidence on the EKC does not seem to depend upon the source of the data, and when an alternative functional form is employed, there is evidence of an inverted-U pattern for the group of OECD countries, with reasonable turning point.

Similarly, Romero-Ávila [28] analyse the time series properties of per capita CO_2 emissions and per capita GDP, for a sample of 86 countries, over the period 1960–2000. The conclusion reveals important implications for the statistical modelling of the Environmental Kuznets curve for CO_2. The results of Granger causality tests obtained by Jalil and Mahmud [29], in China's case, indicate unidirectional causality runs through economic growth to CO_2 emissions, while He and Richard [30], investigating Canada, find little evidence in favour of the environmental Kuznets curve hypothesis. The paper of Iwata et al. [31] estimates the environmental Kuznets curve (EKC) in the case of France taking into account the nuclear energy in electricity production. The causality tests confirm the unidirectional causal relation running from other variables to CO_2 emissions. Shahbaz et al. [32] investigate the relationship between CO_2 emissions, energy consumption, economic growth and trade openness for Pakistan. The result suggests that there is a long run relationship among the variables and EKC is present both for long-and-short runs. Similar results also obtain other researchers, such as: Apergis and Payne [33], who explore the 11 countries of the Commonwealth independent states, for the period 1992–2004; Wang et al. [35], who focus on 28 provinces in China, during 1995–2007; Al-Mulali [37], who uses a panel model approach to analyse the Middle East and North Africa (MENA) countries for 1980–2009; and Nasir and Rehman [34], who find that the energy consumption increases CO_2 emissions both in short and long run, while openness to trade increases energy emissions.

The most recent contributions in the field belong to Farhani and Rejeb [37] and Arouri et al. [38]. The first group of authors use the panel cointegration methods and panel causality test in order to study the energy consumption, economic growth and CO_2 emissions nexus, for 15 MENA countries, covering the period 1973–2008. Their findings show that only in the long run there is a unidirectional causality running from economic growth and CO_2 emissions to energy consumption. Finally, Arouri et al. [38], for the same sample, considering the period 1981–2005, demonstrate poor evidence in support of the EKC hypothesis.

Regarding Romania, Atici [39] studies the connections between gross domestic product (GDP) per capita, energy use per capita and trade openness on carbon dioxide (CO_2) emission per capita in the Central and Eastern European Countries. The EKC performed for Bulgaria, Hungary, Romania and Turkey, confirms the existence of an EKC for this region. Tamazian and Rao [40] consider 24 transition economies (including Romania) and use a panel data for 1993–2004. The authors offer support for the EKC hypothesis, while confirming the importance of both institutional quality and financial development for environmental performance.

Sova et al. [41], using a Multilevel Regression Model (MRM), have focused their study on Romanian's case only. The main finding allows a significant role for collective action and environmental taxes, which suggests some possible policy changes to achieve better environmental outcomes.

3. Econometric specification and methodology

The theoretical underpinnings of relationship between economic growth and energy consumption with emissions have been discussed. This implies that the relationship between economic growth and energy pollutants is termed as environmental Kuznets curve. The EKC hypothesis reveals that economic growth increases energy emissions initially. The main reason is that a major objective of public and private sectors is to support the pace of economic growth through their contribution by creating more jobs without caring about the environmental cost. After a certain level of per capita income, economy starts to adopt environment friendly technology to enhance output in the country due to the rising

demand of cleaner environment as people are more conscious now about environmental quality. This implies that relationship between economic growth and energy emissions should be inverted U-shaped termed as environmental Kuznets curve (EKC).

The relationship between energy consumption and energy emissions can be discussed by economic activity channel in the country. The energy literature points out that a consistent rise in economic growth increases the demand for energy to enhance output level that in return produces high level of energy pollutants. For instance Paul and Bhattacharya [44], Ho and Siu [45], Bowden and Payne [46], and Nasir and Rehman [34] have concluded that high economic growth is linked with high energy consumption which may increase the environmental degradation.

To test the existence of environmental Kuznets curve in the presence of energy consumption, the series have been transformed into natural log-form. The log-linear specification is superior and provides consistent empirical findings, according to Shahbaz [47]. The estimable equation for empirical evidence is modelled as following:

$$\ln CO_{2t} = \alpha_1 + \alpha_2 \ln Y_t + \alpha_3 \ln Y_t^2 + \alpha_4 \ln EC_t + \mu_i \tag{1}$$

where, $\ln CO_{2t}$ is natural log of energy emissions per capita, $\ln Y_t (\ln Y_t^2)$ is economic growth proxied by real GDP per capita (square of real GDP per capita), $\ln EC_t$ is for energy consumption per capita and μ is residual term assumed to be normally distributed in time period t. The hypothesis of EKC reveals that the sign of α_2 is positive i.e., $\alpha_2 > 0$ while that of α_3 is negative i.e., $\alpha_3 < 0$. It implies that economic growth increases energy emissions initially and reduces it when economy is matured. The rising demand for energy will increase energy emissions. Similarly, the sigh of α_4 is positive i.e., $\alpha_4 > 0$.

We have applied the ARDL bounds testing approach to cointegration to test the existence of long run relationship between economic growth, energy consumption and energy emissions in case of Romania using time series data for the period of 1980–2010. The ARDL approach is superior to traditional techniques and is free from the problem of integrating order of the variables. This approach can be applied if variables are integrated at I(1), or I(0) or I(1)/I(0). Another merit of ARDL bounds approach is that, it has suitable properties for small sample data sets like in case of Romania. The dynamic error correction model (ECM) can be derived from the ARDL model through a simple linear transformation (Banerjee and Newman [48]). The error correction model integrates the short-run dynamics with the long-run equilibrium without losing information about long-run. The equations of unrestricted error correction methods for the ARDL bounds approach are modelled as:

$$\begin{aligned}\Delta \ln CO_{2t} = {} & \beta_\circ + \beta_1 T + \beta_2 \ln CO_{2,t-1} + \beta_3 \ln Y_{t-1} \\ & + \beta_4 \ln Y_{t-1}^2 + \beta_5 \ln EC_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln CO_{2,t-i} \\ & + \sum_{j=0}^{q} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{n} \beta_k \Delta \ln Y_{t-k}^2 + \sum_{k=0}^{n} \beta_k \Delta \ln EC_{t-l} + \mu_i \end{aligned} \tag{2}$$

The decision about cointegration among the variables depends upon the critical bounds generated by Pesaran et al. [49]. The hypothesis of no cointegration in Eq. (2) is $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$. The hypothesis of existence of cointegration is $\beta_2 \neq \beta_3 \neq \beta_4 \neq \ \beta_5 \neq 0$. The decision is in favour of cointegration if upper critical bound (UCB) is less than computed F-statistic. There is no cointegration between the variables if computed F-statistic is less than lower critical bound (LCB). If computed F-statistic lies between lower and upper critical bounds then decision about cointegration is questionable.

The goodness of fit of the ARDL bounds testing approach is investigated by applying the diagnostic and stability tests. The diagnostic test is applied to test the serial correlation, functional form, normality of error term and heteroscedisticity in the model. The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) have been conducted to test the stability of the ARDL parameters.

The data on carbon emissions per capita, real GDP per capita and energy consumption per capita has been collected from world development indictors (CD-ROM, 2011). The data span of the study is from 1980 up to 2010.

4. Empirical results and discussions

We have used ADF unit root test to test the stationarity properties of the variables. The results reported in Table 1 show that variables are found to be non-stationary at their level form. After 1st

Table 1
Unit root test.

Variables	ADF Test with intercept and trend	
	T-calculated	Prob-value
$\ln CO_{2t}$	−2.4027	0.3703
$\Delta \ln CO_{2t}$	−3.3982***	0.0743
$\ln Y_t$	−2.6446	0.2651
$\Delta \ln Y_t$	−4.8597*	0.0049
$\ln Y_t^2$	−2.4999	0.3256
$\Delta \ln Y_t^2$	−6.6616*	0.0003
$\ln EC_t$	−2.1427	0.5011
$\Delta \ln EC_t$	−3.7966**	0.0339

* Indicate significance at 1% level.
** Indicate significance at 5% level.
*** Indicate significance at 10% level.

Table 2
ARDL cointegration analysis.

Bounds testing to cointegration		
Estimated equation	$CO_{2t} = f\left(EC_t, Y_t, Y_t^2\right)$	
Optimal lag structure		
Wald-test-statistics	19.400*	
Significant level	Critical values (T=29)	
	Lower bounds, $I(0)$	Upper bounds, $I(1)$
1%	7.977	9.413
5%	5.550	6.747
10%	4.577	5.600
Diagnostic tests	Statistics	
R^2	0.9858	
Adj-R^2	0.9678	
F-statistic (Prob-value)	54.7179 (0.0000)	
J-B normality test	0.2166 (0.8973)	
Breusch–Godfrey LM test	1.9125 (0.2032)	
ARCH LM test	0.5794 (0.4543)	
White heteroskedasticity test	1.6886 (0.1937)	
Ramsey RESET	1.6588 (0.2268)	

* Shows significant at 1% level.

Table 3
Results of test of cointegration.

Hypothesis	Trace statistic	5% CV	Hypothesis	Max. Eigen value	5% CV
$R=0$	72.4618*	47.8561	$R=0$	52.8113*	27.5843
$R \leq 1$	19.6504	29.7970	$R=1$	11.9662	21.1316
$R \leq 2$	7.6842	15.4947	$R=2$	7.6152	14.2646
$R \leq 3$	0.0689	3.8414	$R=2$	0.0689	3.8414

* Indicating the number of cointegration relations.

Table 4
Long run results.

Variables	Coefficient	*T*-statistic	Coefficient	*T*-statistic	Coefficient	*T*-statistic
Dependent variable$=\ln CO_{2t}$						
Constant	−9.5387	−8.4765*	−7.5789	−9.5910*	−7.4645	−11.9131*
$\ln Y_t$	0.0613	2.4239**	0.0658	5.0425*	0.0382	2.1282**
$\ln Y_t^2$	−0.0058	−3.4097*	−0.0062	−6.3977*	−0.0041	−2.9838*
$\ln EC_t$	1.4579	10.5578*	1.2139	12.395*	1.2520	15.585*
DUM_t	…	…	−0.1338	−5.0131*	−0.1139	−4.9849*
$\ln FD_t$	…	…	…	…	−0.1052	−2.0456**
R^2	0.9850		0.9948		0.9934	

* Show significant at 1% level of significance.
** Show significant at 5% level of significance.
*** Show significant at 10% level of significance.

differencing, series do not show unit root problem. It implies that all the series are integrated at I(1). The unique integrating order of the series such as $\ln CO2_t$, $\ln GDP_t$, $\ln GDP_t^2$ and $\ln EC_t$ leads us to apply the ARDL bound testing approach to cointegration to test the existence of long run relationship between the variables Table 2–4.

Before proceeding to the ARDL bounds testing, appropriate lag order of the variables is prerequisite. In doing so, we choose AIC criterion that is preferred due to its power properties and the most suitable for small sample data set. The appropriate lag length of the variables for our sample is 2. The ARDL results reveal that calculated *F*-statistic is 19.400 greater than upper critical bound tabulated by Narayan [50] at 1% level of significance. This confirms the existence of cointegration relation which implies that the variables are tied together for long run relationship over the study period in case of Romania.

At 5% significance level, all diagnostic tests do not exhibit any evidence of violation of the classical linear regression model (CLRM) assumptions. Specifically, Jarque–Bera (J–B) normality test cannot reject the null hypothesis, meaning that the estimated residual has normality distribution and standard statistical inferences are valid. At the same level of significance, both Breusch–Godfrey LM test and ARCH LM test consistently reveal that the residuals are not serially correlated, and are also free from heteroskedasticity problem. There is no specification problem with the model.

It is indicated that all series such as economic growth, energy pollutants and energy consumption have unit root problem at their level form while are found to be stationary at 1st difference. It implies that the variables are integrated at I(1). This unique level of integration leads us to use Johansen multivariate approach to cointegration for robustness of long run relationship. The findings show that there are two cointegration vectors between economic growth, energy consumption and energy pollutants in case of Romania which confirms the robustness of long run relation.

Existence of cointegration relation between the variables leads us to find the marginal impacts of economic growth and energy consumption on energy pollutants. The results indicate positive impact of economic growth on energy emissions. This shows Romanian economy is achieving growth at the cost of environment. A 1% increase in economic growth is linked with 0.0613% increase in CO_2 emissions. The empirical evidence pointed out that energy consumption is a major contributor to energy emissions. The effect of energy consumption is positive and highly significant. A 1.4579% increase in energy emissions is associated with a 1% increase in energy consumption. This fact claims renewable sources in overall energy mix and energy efficiency projects in residential buildings, industry, and transports. The Romanian's Government must stimulate the acquisition of the new technology, with high level of energy efficiency and low degree of pollution.

The existence of environmental Kuznets curve is also investigated by incorporating squared term of $\ln GDP_t$ i.e., $\ln GDP_t^2$. The results indicate positive (negative) effect of linear (nonlinear) economic growth on energy emissions i.e., inverted U-shaped relation. This finding confirms the existence of environmental Kuznets curve in case of Romania. The EKC relationship between economic growth CO_2 emissions reveal that economic growth increases energy emissions initially and declines it when economy achieves a certain level of income per capita during economic development. In Romania, economic growth has illustrated, in the second half of '2000, accentuate ascendant trend, especially as the results of the flat tax rate by 16%, introduced since 2005. In this context, a lot of foreign companies have started to perform their activity in Romania. By consequences, the new and modern technologies implemented have determined a limitation of CO_2 emissions.

Moreover, "Integrated pollution prevention and control (IPPC Directive)" directive of the European Union has introduced new restrictions regarding CO_2 emissions. Based on this directive, since 2012 the companies from EU must use the most recent ecological technology. These findings are consistent with the empirical evidence of He [51], Song et al. [52], Halicioglu [53], Fodha and Zaghdoud [25], and Shahbaz et al. [32].

The effect of democracy is inversely linked with energy emissions. The negative sign of DUM (democracy) confirms the efforts done by government to save environment from degradation.[2] In Romania, before 1989, in the communist autocratic political regime, the state monopolized in the private sector generated seriously environment problems. The state companies, to ensure lowest production costs, utilized an obsolete technology, with low efficiency and high level of energy emissions. Since 1990, the new democratic regime has made strong steps to attenuate the energy emissions, especially after the integration of the country in EU in 1997.

Finally, financial development exerts inverse impact on energy emissions. This implies that financial development contributes to control environmental degradation by monitoring the loans to firms.[3] It found that a 1% increase in financial development will reduce environmental degradation by 0.1052% significantly. This finding supports the view by Tamazian et al. [54], Tamazian and Rao [40], and Jalil and Feridun [55], that financial development declines energy emissions. In Romania, based on the positive economic growth trend, this fact is connected with the companies' financial power, which can permit a strong individual control of energy emissions, as a consequence of modern environmental policy promoted especially after 1997. More, a welcome financial aid has arrived from UE, through the structural financial programs in the environment field.

The short run dynamics are reported in Table 5 and results indicate that linear and non-linear terms of real GDP per capita

[2] We have used $D=1$ for democracy otherwise zero.
[3] Domestic credit to private sector as share of GDP is used as proxy for financial development. This indicates actual level savings that is distributed to private sector by financial institutions (Shahbaz [47]).

have positive and negative impact on energy emissions indicating the validation of environmental Kuznets curve (EKC). Energy consumption has positive and strong effect to increase energy pollutants. By consequence, if the communist regime tolerated the energy emissions in order to obtain a high output level, but with expensive costs, the actual democratic authority must stimulate energy efficiency, with a low amount of energy emissions. In this way, the Romanian actions follow the EU general energy policy.

The significance of error correction term implies that change in the response variable is a function of disequilibrium in the cointegrating relationship and the changes in other explanatory variables. The coefficient of ECM_{t-1} shows speed of adjustment from short-run to long-run and it is statistically significant with negative sign. Banerjee et al. [56] noted that significant lagged error term with negative sign is a way to prove the established long-run relationship is stable. The deviation of energy emissions from short-run to the long-run is corrected by 87.68% each year.

In addition, the model passes all diagnostic tests for non-normality of error term, serial correlation, autoregressive conditional heteroskedasticity, white heteroskedasticity and model specification. Finally, the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) are applied. The plots of CUSUM and CUSUMSQ statistics are presented.

Fig. 2 shows the plot of cumulative sum of recursive residuals (CUSUM) is not consistent after the 4th quarter of 2005 and indicates structural break in the economy. In this year, the Romanian's Government made a major tax correction, introducing the flat tax rate of 16%, for almost all revenues of companies and individuals. Unfortunately, this change led to higher imports of manufactured goods, with negative effects on the current account balance. Moreover, this tendency was stimulated by the rise in the amount of loans, based on the low level of monetary policy interest rate and the low level of reserve requirement ratio. The cumulative sum of squares of recursive residuals (CUSUMSQ) points out that the ARDL parameters are stable (Fig. 3).

It is argued by Leow [57] that graphs mostly mislead the empirical evidence. To avoid this problem, we have applied Chow forecast test to test the significance structural break point in case of Romania for the period 1980–2010. *F*-statistic is reported in Table 6 and shows that there is no structural break in Romanian economy. It implies that Chow forecast test is more reliable and preferable than graphs.

Table 5
Short run results.

Variable	Coefficient	*T*-statistic	Prob-value
Dependent variable $=\Delta \ln CO_{2t}$			
Constant	−0.0071	−0.9806	0.3374
$\Delta \ln Y_t$	0.1127	2.3783	0.0265
$\Delta \ln Y_t^2$	−0.0076	−2.5476	0.0183
$\Delta \ln EC_t$	1.5345	8.1198	0.0000
ECM_{t-1}	−0.8768	−2.3247	0.0297
Diagnostic tests		*F*-statistic	Prob-value
$\chi^2 SERIAL$		1.9034	0.1573
$\chi^2 ARCH$		1.5251	0.2288
$\chi^2 WHITE$		1.4518	0.2506
$\chi^2 REMSAY$		0.4051	0.5313

5. Conclusion and policy implications

The issue of global warming has been rising since 1990s and economies of the globe are busy to save environment by implementing environmental policies. Extensive literature is available on the

Table 6
Chow forecast test.

Chow forecast test: forecast from 1980 to 2010			
F-statistic	1.9014	Probability	0.1441
Log likelihood ratio	11.8740	Probability	0.0366

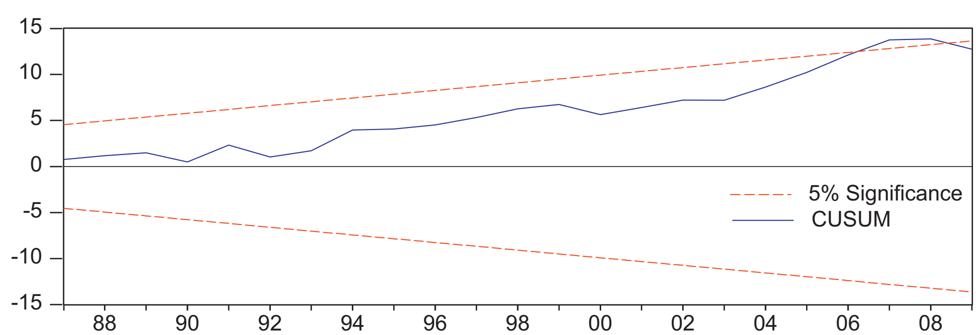

Fig. 2. Plot of cumulative sum of recursive residuals: Romania 1980–2010. The straight lines represent critical bounds at 5% significance level.

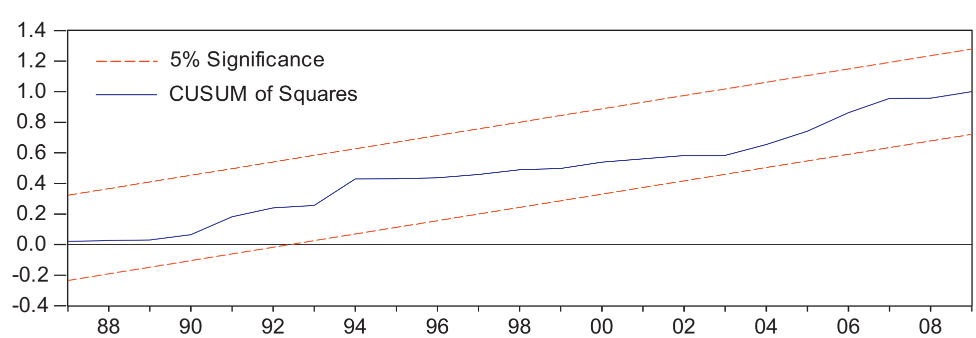

Fig. 3. Plot of cumulative sum of squares of recursive residuals: Romania: 1980–2010. The straight lines represent critical bounds at 5% significance level.

relationship between economic growth and energy pollutants. The so-called relationship between both variables is termed as environmental Kuznets curve (EKC) i.e., inverted U-shaped between income per capita and environmental degradation.

This study has explored the dynamic relationship between income per capita, energy consumption per capita and CO_2 emissions per capita using time series data for the period of 1980–2010. In doing so, the ARDL bounds testing approach to cointegration is applied to investigate long run relationship between the variables. The ADF unit root test is used to test the order of integration of the variables. Our results confirm the cointegration which further validates the existence of long run relationship between economic growth, energy consumption and energy pollutants. The empirical evidence reveals that the Environmental Kuznets curve (EKC) is confirmed both in long-and-short runs in case of Romania. Further, energy consumption is major contributor to energy pollutants.

Democratic regime shows her significant contribution to decline CO_2 emissions through effective implementation of economic policies and financial development improves environment i.e., reduces CO_2 emissions by redirecting the resources to environment friendly projects. In this context, the main objective of the first Environment Department in Romanian's history was the limitation of pollution phenomena, and the establishing of responsibility regarding environmental damage. Unfortunately, in early 1990s, the Romanian government did not have a real and coherent environmental policy.

This gap, with very lax environmental restrictions, was exploited by several foreign companies, which made delocalisation in Romania, using the advantage of low level of CO_2 emissions costs. Based on EU regulations, the first official document for environment conservation and protection, named National Strategy of Environment Protection, was signed in 1992 and updated in 1996, and 2002.

Since 2007, when Romania became an EU member, the environmental policy has been focused on new coordinates. According to EU agreement, Romania must increase the share of renewable sources in the overall energy mix and energy efficiency projects in residential buildings, industry, and transports (the costs are estimated to 6.1 billion Euros until 2015). In this context, the exploration of the new alternative energy resources, such as hydroelectric power plants, thermal power plants and wind power plants, are more than welcomed. Furthermore, in our opinion, the Romanian authority could use other several policy instruments to combat the energy pollutants, such as: the restructuration of environmental taxes and the incentive of population behaviour in the environmental proactive area. In the EU, Romania remained the country with the lowest level of environment taxation as per cent of GDP, being absolutely necessary a revision of taxation rates for all three main types of taxes in the field: energy, transport, and pollution taxes. An additional need is a substantial improvement on taxes collection. On the other hand, in order to diminish the energy pollution, the Romanian authority must coagulate a strong cooperation between the main public actors: the Government, the patronages, the educational institutions, the non-governmental organizations, and the citizens.

Appendix

Please see appendix (Fig. A1), Tables (A1–D1).

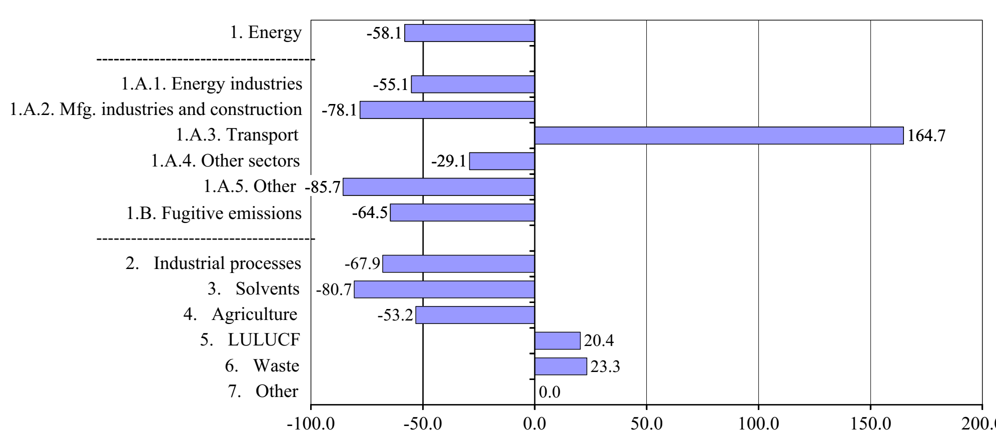

Fig. A1. Change in GHG emissions/removals from 1989 to 2010 (%).
Source: United nations framework convention on climate change, GHG data, 2012.

Table A1
Resources used for production of electric energy.
Source: Calculated based on "Energetic balance of Romania", 2007–2010, NIS.

Electric energy based on	Year/percent in total							
	2007		2008		2009		2010	
	(Mil.kW h)	(%)	(Mil.kW h)	(%)	(Mil.kW h)	(%)	(Mil.kW h)	(%)
Coals	25,096	66.05	25,824	70.69	21,727	71.36	20,675	71.77
Hydrocarbons	12,319	32.42	10,489	28.71	8,509	27.95	7,753	26.91
Liquid hydrocarbons	759		568		877		500	
Gaseous hydrocarbons	11,560		9,921		7,632		7,253	
Renewable energy and other fuels	581	1.53	218	0.60	212	0.70	378	1.31
Total	37,996	100	36,531	100	30,448	100	28,806	100

Table B1
Consumption of coal in energy sector.
Source: Calculated based on "Energetic balance of Romania", 2007–2010, NIS.

No.	Coal consumption in energy sector	Year/percent in total							
		2007		2008		2009		2010	
		(Gj)	(%)	(Gj)	(%)	(Gj)	(%)	(Gj)	(%)
		7,888,118	100	8,339,133	100	5,676,054	100	6,878,323	100
1	Bituminous coal	0	0.00	27,308	0.33	0	0.00	0	0.00
2	Coking coal	0	0.00	0	0.00	0	0.00	0	0.00
3	Coke & semi coke	0	0.00	0	0.00	0	0.00	0	0.00
4	Energetic pit coal	21,008	0.27	153,943	1.85	120,364	2.12	525,379	7.64
5	Other coals	3,933,555	49.87	4,078,941	48.91	2,777,845	48.94	3,176,472	46.18
6	Lignite	3,933,555	49.87	4,078,150	48.90	2,777,845	48.94	3,152,153	45.83
7	Brown coal	0	0.00	791	0.01	0	0.00	24,319	0.35

Table C1
Consumption in energy sector.
Source: Calculated based on "Energetic balance of Romania", 2007–2010, NIS.

Nr.	Consumption in energy sector	Year/percent in total							
		2010		2008		2009		2010	
		(Gj)	(%)	(Gj)	(%)	(Gj)	(%)	(Gj)	(%)
1	Coals	7,888,118	7.38	8,339,133	7.46	5,676,054	6.53	6,878,323	7.18
2	Firewood, including biomass	203,547	0.19	159,217	0.14	136,362	0.16	56,666	0.06
3	Crude oil	25,960	0.02	17,346	0.02	133,227	0.15	1,524	0.00
4	Naphtha	60,300	0.06	49,342	0.04	5,669	0.01	43,920	0.05
5	Oils (including White-Spirit)	1,124,886	1.05	281,076	0.25	17,229	0.02	585,034	0.61
6	Diesel oil	863,969	0.81	1,553,662	1.39	2,260,378	2.60	2,175,056	2.27
7	Fuel oil	6,122,528	5.73	3,995,495	3.58	2,786,722	3.21	7,096,959	7.41
8	Refinery gas (including propylene)	23,996,964	22.46	28,865,686	25.83	23,459,338	26.99	23,152,538	24.18
9	Liquefied petroleum gas (LPG)	112,453	0.11	1,915,459	1.71	1,768,021	2.03	1,932,335	2.02
10	Other products (kerosene, petroleum coke, petroleum bitumen, mineral oils, paraffin)	26,785,270	25.07	27,166,755	24.31	15,074,645	17.34	16,001,433	16.71
11	Natural gas	32,666,306	30.57	33,022,917	29.55	31,385,487	36.10	37,401,332	39.06
12	Coke gas	5,561,169	5.20	5,004,352	4.48	1,589,320	1.83	0	0.00
13	Gas Furnace	1,395,706	1.31	963,413	0.86	808,914	0.93	378,644	0.40
14	Other fuels (pit coal, industrial waste, liquid bio fuels)	52,242	0.05	382,248	0.34	1,805,290	2.08	0	0.00
15	Unconventional energy sources	0	0.00	38,823	0.03	24,466	0.03	48,638	0.05
16	Total	106,859,418	100	111,754,924	100	86,931,122	100	95,752,402	100

Table D1
GHG emission per kW h electricity production in Europe.
Source: according to Dones et al. [58]

	Minimum (kg CO_2-equiv./kW h)	Maximum (kg CO_2-equiv./kW h)
Lignite	1.060	1.690
Hard coal	0.949	1.280
Oil	0.519	1.190
Industrial gas	0.865	2.410
Natural gas	0.485	0.991
Nuclear power	0.008	0.011
Hydropower	0.003	0.027
Wind power	0.014	0.021
PV (mix mc & pc)[3]	0.079	–
Wood congeneration	0.092	0.156

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